

THE STUDY OF TURBELLARIANS (PLATYHELMINTHES) AT THE QUEENSLAND MUSEUM

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Angus, B.M. 2007 11 30: The study of turbellarians (Platyhelminthes) at the Queensland Museum. *Memoirs of the Queensland Museum* 53(1): 157-185. Brisbane. ISSN 0079-8835.

Turbellarian research was largely ignored in Australia, apart from some early interest at the turn of the 19th century. The modern study of this mostly free-living branch of the phylum Platyhelminthes was led by Lester R.G. Cannon of the Queensland Museum. A background to the study of turbellarians is given particularly as it relates to the efforts of Cannon on symbiotic fauna, and his encouragement of visiting specialists and students. The collections of turbellarians now held at the QM include the largest representations of the Temnocephalida and Polycladida in the world, and substantial collections on meiofaunal species in several groups. In 1996 Cannon convened the 8th International Symposium on the Biology of the Turbellaria at the Queensland Museum. □ *Turbellaria, collections, history, biography. Queensland.*

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A former Director of the Queensland Museum, Dr William Haswell (Fig. 1), one of Australia's foremost biologists, contributed enormously to the study of turbellarians in this country, though not until after he had left the Museum for the University of Sydney. Prior to 1976 when Lester R.G. Cannon joined the Queensland Museum as Curator of Lower Invertebrates, the study and collections of turbellarians at the museum barely existed. Cannon had trained as a parasitologist and was then the only curator of any Australian museum with parasitological training. His new responsibilities, however, were much broader than just parasites and he made the decision to study the 'Turbellaria' as the precursors of the parasitic flatworms. He is now acknowledged internationally as an expert in the group. He retired in 2002.

C.G. Ehrenberg in 1831 described the Turbellaria, for those organisms distinguished by their ciliated epidermis and the presence of 'water vascular systems' (protonephridia). Subgroups were distinguished on the basis of differences in the structure of the gut. Ehlers (1864) defined turbellarians as 'bilaterians without rigid skeletons, but with tubular reinforcements between epidermis and body-wall musculature, all of which function together as the main system of locomotion'.

The Class Turbellaria was placed in the Phylum Plathelminthes [Platyhelminthes] by Minot (1876) and these worms are now known as an assemblage of mostly free-living platyhelminthes, although the phylum is best known for its parasitic tapeworms and flukes.

EARLY STUDIES

Readily visible parasitic flatworms were recorded in an ancient Egyptian papyrus as early as 1550 BC, but the first turbellarians to be scientifically described were in the 18th and 19th centuries. The first monographic treatises on the 'Turbellaria' were written by von Graff (1882, 1891, 1899), Lang (1884) and Wilhelmi (1909), and from the end of the 19th and beginning of the 20th century a major centre for turbellarian research developed with von Graff in Graz, Austria. Nineteenth century researchers included Eli Metchnikoff (1877, 1878) who carried out developmental studies on turbellarians. Europe has continued to dominate studies to this day, though important work has been done in the USA by Hyman, in Brazil by Marcus and Marcus and in Japan by Ijima and Kaburaki.

Early publications reflected a concerted effort to study the group and are so comprehensive they remain useful references today, since, in addition to summarising what was then known of the morphology, physiology and systematics of flatworms, these treatises also catalogue knowledge acquired chronologically. Before von Graff's 1882 publication, which was the first comprehensive monograph on turbellarians, an illustration had been made by Trembley (1744) which von Graff identified as being a dark freshwater triclad [i.e. a planarian]. O.F. Müller (1773, 1776) conducted the first taxonomic studies of turbellarians and coined the name Planarien for them, following which interest in the taxon grew in Europe, North America and in Russia.



FIG. 1. William Haswell, former Director of the Queensland Museum, leading early authority on turbellarians in Australia, especially temnocephalans. From, 'William Aitcheson Haswell, 1854-1925', Proceedings of the Linnean Society of New South Wales, vol. 53, pp. 485-498. 1928.

Sir J.P. Dalyell's (1814) studies had a profound impact on the advancement of turbellarian research in the early 19th century. He is recognised for noting the tremendous regenerative powers of certain turbellarians, having described spontaneous fission in *Planaria felina* as a regular means of reproduction. Von Baer (1827) reported the bisexual nature of turbellarians.

It is of great interest that in 1844 Charles Darwin described ten species of land planarians from Tasmania, with notes on their behaviour, ciliary gliding and their 'artificial' fission. In 1995 Professor R.D. Keynes, FRS, of Cambridge, sent to Dr David Gibson at the British Museum of Natural History in London, a 368 page unpublished manuscript written by Charles Darwin in 1844, titled 'Zoology Notes from H.M.S. Beagle', which included notes on polyclad turbellarians. Gibson contacted L.R.G. Cannon at the Queensland Museum with a specific enquiry regarding six planarians and Cannon attempted to identify the specimens from Darwin's descriptions. He recognised Darwin's *Diplonaria notabilis* Darwin, 1844 as *Leptoplana notabilis* (Darwin, 1844) Diesing, 1862 and referred Professor

Keynes to Stephen Prudhoe's *Monograph on Polyclad Turbellaria* (Prudhoe, 1985).

During the early part of the 20th century, studies on regeneration, physiology and behaviour often accompanied morphological and histological investigations, but only research on regeneration developed into a field of its own. General knowledge of the turbellarians was summarised four times during the last century by Bresslau (1928-1933), Meixner (1938), Hyman (1951) and Beauchamp (1961).

DEVELOPING SOPHISTICATION

Electron microscopy had a profound impact on morphological studies which led to a new phylogenetic system of the Platyhelminthes as a whole, with emphasis being placed on the paraphyletic nature of the 'Turbellaria' within that phylum (Ehlers, 1985b). Other advances in methodology include immunocytochemistry, the molecular biology of nucleic acids, karyology and computational methods. Contemporary research on the physiology of food uptake, digestion and defaecation has been undertaken by J.B. Jennings (*vide infra*).

Professor Peter Ax, University of Göttingen, initially studied meiobenthic turbellarians (1951, 1956a, 1959) and carried out major systematic revisions (1956b). He conducted zoogeographic analyses of turbellarians from Europe, Galapagos, Asia and North Polar regions (Ax & Armonies, 1987, 1990) and has extensively described new species and studied reproductive and developmental biology (Ax, 1966, 1969). Under his tutelage Göttingen became a centre for turbellarian studies, with leading students Ulrich Ehlers and Beate Sopot.

The Japanese school of developmental biology of polyclads and the biology and systematics of triclads in Japan, includes the work of Isao Ijima, Kojiro Kato, Tokio Kaburaki, I. Okuagawa, B. Ito and more recently, Masaharu Kawakatsu.

Evolution of turbellarian organ systems have been elucidated by Tor G. Karling in Stockholm (Karling, 1940, 1963, 1970, 1974a, b), first with light microscope histology studies which were later confirmed through electron microscopy analysis. Among many to study the morphology, phylogeny, ontogeny and ecology of marine and freshwater micro- and macroturbellarians was Reisinger (1923, 1976) and Reisinger, & Steinböck (1927) but perhaps the most comprehensive

summary of turbellarian biology is that recorded by Libbie Henrietta Hyman (1951).

Electron microscopy studies during the 1960s, 1970s and 1980s have profoundly affected concepts of turbellarian morphology, resolving questions as to whether certain tissues are cellular or multinucleated. Phylogenetic questions are solved through being able to view the organisation of germ cells, and fine-structure analysis of adults and of developmental stages of symbiotic and non-symbiotic turbellarians has facilitated a better understanding of the evolutionary origin of the Neodermata i.e. the non-turbellarians, the purely parasitic groups of platyhelminths. The ultra-structural information revealed by electron microscopy has prompted speculation on the phylogenetic relationships of platyhelminths. By rigorous application of cladistic principles, the paraphyletic nature of the 'Turbellaria' has become evident (Ball, 1974a; Ax, 1984, 1987 & 1996; Ehlers, 1984, 1985a, b. Sopott-Ehlers & Ehlers, 1995). It was concluded that in order to understand platyhelminth phylogeny, it was necessary to consider turbellarian taxa in juxtaposition to the Neodermata.

Turbellarian taxonomy has traditionally relied on information from the entire organisational hierarchy, from behaviour to cytology. Taxonomy

is more than describing new species, careful taxonomic revisions and reviews of systematic groups are equally important. Publications such as Cannon's (1986) *Turbellaria of the World* advances turbellarian systematics by summarising the taxonomy of the turbellarians as a whole and facilitating work with turbellarians by non-specialists.

TURBELLARIAN STUDY IN AUSTRALIA

It began with Darwin (1844) and Schmarda (1859). Macroscopic animals such as triclads especially terrestrial worms were studied by Spencer (1891) and Dendy (1891). Contemporary study has been conducted by Winsor (1998) (Fig. 2); Ian Ball made a short foray into the study of the freshwater triclads (Ball, 1974a, b, 1977a, b). The exclusively marine macroscopic polyclads were studied by Laidlaw (1903) and Haswell (1907) and more recently by Hyman (1959) and Prudhoe (1977). Symbiotic worms especially the Temnocephalida which live externally on crayfish were studied by Haswell (1893) and more recently by Hickman (1956, 1967) (Fig. 3) who studied, not only temnocephalans in Tasmania, but endosymbionts of echinoderms also. These two groups, echinoderm symbionts and temnocephalans, have been those to which Cannon has devoted most of his attention. Study of free-living microturbellarians began with Schmarda (1859), but remained virtually untouched subsequently until Cannon promoted their study by visiting scholars.

CANNON'S MOTIVATION TO STUDY TURBELLARIA

When Cannon joined the Queensland Museum in November 1976 as Curator: Lower Invertebrates, he was responsible for about 20 phyla including protozoans, annelids, sponges, coelenterates, sipunculids and nemerteans, as well as the parasitic helminths (Platyhelminthes, Nematoda, Nematomorpha and Acanthocephala). His appointment to the Queensland Museum was a pivotal point in his career, since he was responsible for different zoological areas plus parasitology. However, facilities for continuing parasitology studies were not as suitable at the Queensland Museum as they had been at the University of Queensland. He thus decided to investigate turbellarians as the forerunners of the major parasitic flatworms, later to be known as the Neodermata. Though most turbellarians are free-living, examples of symbiotic (even



FIG. 2. Leigh Winsor, ISBT VIII, Brisbane, 1996.



FIG. 3. Prof. V.V. Hickman in 1982. From C.N. Smithers 1985 "Tribute to V.V. Hickman" *General and Applied Entomology* 17: 3-4.

parasitic) life styles are scattered through the group (Cannon, 2005). In the 1970s there was no synopsis of the turbellaria which would enable zoologists to 'get to first base' in identifying members of that group, as compared with Yamaguti's *Systema Helminthum* on helminthology.

Cannon's 'springboard into turbellarian studies' was the Proceedings of the Hyman Memorial Conference held in Chicago in December 1970 (Riser & Morse, 1974). Published in 1974 as *The Biology of the Turbellaria*, it provided an English language compendium of turbellarian work and the names and fields of interest of the most prominent turbellarian workers of the day. Cannon considers this publication to have been pivotal in promoting turbellarian research in the latter part of the 20th century. Furthermore, it spawned the convening of subsequent conferences on the 'Turbellaria'.

To get to know the various groups of 'Turbellaria' Cannon contacted an established expert, Professor Peter Ax, who was working on the Island of Sylt off the northwest coast of Germany near the Danish border. He sought to go to Germany for 12 months to study the systematics of the indigenous turbellarian fauna of Sylt and undertook night classes in German to acquire a basic knowledge of the language and

to be able to read journal articles. Professor Ax was influential with the Von Humboldt Scheme and indicated his willingness to assist Cannon in securing a 2-year Humboldt Fellowship to work with him from 1983. The Queensland Museum, however, was unable to release Cannon for such a long period, but granted him five weeks' study leave. Adding three weeks' vacation leave, Cannon proceeded, in May 1983, to Europe for eight weeks to confer with established turbellarian experts.

In addition to visiting Professor Ax, Cannon visited Professor Tor Karling (Fig. 4) in Stockholm to whom he showed a pictorial key which he had compiled on the turbellarian groups in general and which he had developed in part by sampling the local fauna. Karling was enthusiastic about Cannon's key and urged him to publish his work. Encouraged by Karling's enthusiasm, Cannon began developing his book. Regarding polyclads, he corresponded with Stephen Prudhoe at the British Museum of Natural History in London, and Anno Faubel, a former student of Peter Ax, in Germany. Prudhoe was preparing a monographic treatment of polyclads (Prudhoe, 1985) and Faubel had just published a radical new treatment (Faubel, 1983, 1984). Prudhoe strongly disapproved of some of Faubel's conclusion, and in compiling his own book, Cannon opted to follow Prudhoe's more conservative and more recent treatment of the polyclads. Cannon did, however, correspond with Faubel during this period and was invited to collaborate with him on a treatment of 'Turbellarians' for a book chapter he was preparing on meiofauna (Cannon & Faubel, 1988).

Cannon subsequently attracted a funding grant from the Australian Bureau of Fauna and Flora which enabled him to produce his book *Turbellaria of the World. A Guide to Families and Genera* published by the Queensland Museum in 1986. Drawn from various sources, the information therein provides a comprehensive introduction to the identification of turbellarian worms by the use of pictorial keys with accompanying notes – 'pictures with words'.

Libbie Henrietta Hyman is perhaps the 20th century's most notable invertebrate biologist, largely because of her monumental volumes *The Invertebrates*, but her major life's work was with turbellarians. Nine symposia have marked progress in research on the turbellarians since the 1970's, the first being held in Chicago in December 1970 as a Memorial to Libbie Hyman who died in 1969.



FIG. 4. Prof Tor Karling in his office at the Swedish Museum of Natural History Stockholm, 1983.

INTERNATIONAL CONFERENCES ON 'TURBELLARIA'

THE FIRST. The first international conference on 'Turbellaria' was held in Chicago in December 1970 as a Memorial to Dr Libbie Henrietta Hyman. Proceedings of the conference, *Biology of the Turbellaria*, edited by Riser & Morse were published in 1974.

THE SECOND. The second conference, in honour of Professor Alex Luther was held in 1977, in Finland. The Proceedings were edited by Karling & Meisener and appear in *Acta Zoologica Fennica*.

THE THIRD. In 1980, a third conference was held in Diepenbeek, Belgium. The Proceedings, also titled *Biology of the Turbellaria*, were edited by E.R. Schockaert & I.R. Ball.

THE FOURTH. The fourth conference was held in New Brunswick, Canada, in 1984 convened by Michael Burt, a parasitologist. Proceedings published in 1986 were titled *Advances in the Biology of the Turbellarians and Platyhelminthes*.

Cannon was able to attend this New Brunswick conference, and took with him print-outs of his pictorial keys which he distributed to turbellarian specialists attending the conference with the

request that they check them for accuracy. He subsequently built up valuable correspondence with these experts.

THE FIFTH. In August 1987, the fifth conference was held at Göttingen, Germany, but Cannon was unable to attend. The Proceedings, *International Symposium on the Biology of the Turbellarians*, were edited by Peter Ax, Ulrich Ehlers & Beate Sopot-Ehlers and published in 1988.

THE SIXTH. Cannon was present at the sixth conference on 'Turbellaria' held in Hirosaki, Japan, in August 1990. *Proceedings of the Sixth International Symposium on the Biology of the Turbellaria* were edited by Seth Tyler.

THE SEVENTH. In August 1993, the seventh International Symposium on the Biology of the 'Turbellaria' was held at Abo/Turku in Finland. Proceedings of this conference, *Biology of the Turbellaria and some related flatworms*, were edited by Lester R.G. Cannon and published in 1995.

THE EIGHTH. In August 1996, Cannon convened the Eighth International Symposium on the Biology of the 'Turbellaria' held in Brisbane, Queensland. The Proceedings sub-titled *Worms Down Under* were edited by Schockaert, Watson & Justine and published in 1998.

In the preface to the proceedings, Cannon pointed out that this was the first such symposium to be held in the Southern Hemisphere and commented that it was the last symposium on the 'Turbellaria' for the millennium. It marked the end of one era and heralded a new one destined to reveal exciting new developments – it was about 'old themes and new perspectives'. The keynote address by Reinhardt Rieger, "100 years of Research on 'Turbellaria'" (Rieger, 1998) encapsulated this transitional state and Cannon regards it as mandatory reading for all new (and a few old!) students of the turbellarians.

It was at this eighth international symposium that the International Society of Flatworm Biologists was founded (although it subsequently foundered).

THE NINTH. In July 2000 the ninth International Symposium on the Biology of the Turbellaria was convened in Barcelona by Jaume Baguna. The Proceedings were published in the Belgian Journal of Zoology edited by Ernest Schockaert. Cannon was unable to attend.

THE TENTH. A 10th International Symposium on the Biology of the Turbellaria, in a revised format, was held in Innsbruck, Austria, in 2006.

CONTACTS AND STIMULUS. As a result of Cannon's first trip in 1983, publication of his book *Turbellaria of the World* in 1986, his attendance at three international conferences on Turbellaria and his convening the eighth conference in Brisbane, he established valuable personal links with a number of international scientists. As one of the few research centres in Australia where research is carried out on turbellarian biology, Cannon was successful in attracting visiting scholars from England, Italy, Russia, Denmark and Sweden who have come to Australia to work at the Queensland Museum. They also helped him to identify Australian turbellarians of which the Queensland Museum has the foremost collection in Australia.

As part of his European travels in 1983, Cannon visited Chris Christensen in Denmark, an authority on a little known parasitic group of turbellarians the Fecampiidae and later Ian Ball in Amsterdam before visiting England where he became acquainted with Dr J.B. ('Joe') Jennings of the University of Leeds. Jennings had been working in Toronto with David Metrick on aspects of nutrition of the turbellarians at the time of Cannon's doctoral candidature at the University of Toronto though they did not meet at that time. Jennings was to subsequently visit the Queensland Museum on several occasions as a visiting scientist and he and Cannon have published a number of collaborative papers (*vide infra*).

VISITING SCIENTISTS AT THE QUEENSLAND MUSEUM

IAN BALL

Ian Ball (Fig. 5) was an Englishman who had been a PhD student at the University of Toronto at the same time as Cannon's PhD candidature there. Ball worked at the Royal Ontario Museum however and although the Museum was close to the University of Toronto, he and Cannon never met, although Cannon knew of him. Ball became a turbellarian expert specialising in freshwater triclads (Paludicolans).

In 1982, Ball visited Cannon at the Queensland Museum during his 6-month study leave in Adelaide on an ABRs grant for taxonomic studies of Australian freshwater triclads. In Adelaide, Ball was working with Professor Bill Williams,



FIG. 5. Ian Ball.

at that time leader of the main limnology school in Australia. Ball was by then an internationally recognised and universally respected authority on the evolution and biogeography of freshwater planarians and had published on collections of these triclad worms in Australia (Ball, 1974a, b, 1977a, b; Ball & Tran, 1979) although he had not visited Australia prior to 1982. In late 1982, Ball joined John Hay, a geneticist from La Trobe University who had been interested in twinning. Hay had taken a keen interest in triclads and collected several from the high country of Victoria (Hay & Ball, 1979). Earlier, they had collected a proseriate from Macquarie Island (Ball & Hay, 1977). They travelled to Brisbane together, calling on Professor Richardson, a retired Professor of Zoology from Auckland University who was then Australasia's leading leech expert. It was during this visit that Ball spent several days with Cannon at the Queensland Museum ensuing to Cannon having corresponded with Ball during his own early research into the turbellarian group. In Brisbane, Ball did some collecting at Moggill. Later he also visited Leigh Winsor at James Cook University (JCU) of North Queensland in Townsville, and the 'Red Centre' and Darwin in the Northern Territory. At the time of Cannon's visit to Ball in Amsterdam in 1983, Ball was Professor of Zoology at the Zoological Museum of the University of Amsterdam. A post-graduate student of Ball's, Ronald Sluys, was working on *Maricola*, the marine triclad planarians, and Sluys is now the undisputed world leader in this group (Sluys, 1989). Sluys published a paper on a freshwater macrostomid turbellarian (Sluys, 1986), and one on a proseriate (Sluys & Ball, 1985) which Ball had collected in the Northern Territory the previous year. There was no publication on any of the triclad material collected by Ball on that Australian visit.

Ball subsequently moved to the Memorial University of Newfoundland at St Johns as Head of the Department of Biology, taking with him several collections of flatworm material. These included extensive collections of Australian material collected by Ball, under permit, from freshwaters in various states of Australia. Additionally, he had gathered relevant flatworm specimens held in Australia by museums and from private collections in order to carry out anatomical investigations at the University of Amsterdam and to publish his results. Much of the Australian material collected by Ball was unique and of particular taxonomic significance, as several new genera and species were involved from different sites. Furthermore, whilst at Memorial University Ball requested Cannon to forward to him all of Cannon's own material on freshwater planarians which Cannon and Jennings had collected on a trip to Tasmania (*vide infra*). Cannon duly dispatched this material but regrettably no publications have been forthcoming from Ball on any of the Australian material nor on material he had removed from Amsterdam. Ball stood down as Head of Department at Memorial University and left to take up the Chair of Zoology at the University of the West Indies in Kingston, Jamaica, taking with him the collections he had acquired from various sources. In an effort to retrieve this material, personal approaches were made to Ball by Cannon at the Queensland Museum in Brisbane, Sluys at the University of Amsterdam, Leigh Winsor at JCU in Townsville, Dr Jean Just of the Australian Biological Resources Survey and by Professor Maraharu Kawakatsu of the Fuji Women's College in Sapporo, but Ball did not respond. In February 2000, advice was received from Dr D.T.J. Littlewood, Wellcome Senior Research Fellow in Biodiversity at London's Natural History Museum, that Ball had died in Kingston, Jamaica, on 26th January 2000. Ball's contribution to turbellarian and evolutionary biology was immense. It is indeed a great pity that the Australian and other material in his care, has been neglected. With the help of Tim Littlewood in the Natural History Museum in London, Ball's collections have been found and passed on to Ron Sluys and he is to attempt a resolution of the material and a return of it to the appropriate institutions.

J.B. ('JOE') JENNINGS

Dr Joe Jennings (Fig. 6) was Reader in Zoology at the University of Leeds, England, and a specialist in the digestive physiology of the 'Turbellaria'.

Early in his career he had attended a conference in California at which Professor Peter Ax was present. Significantly, he also attended the Hyman Memorial Conference in Chicago in 1970.

Jennings had been a visiting scientist working with David Mettrick at the University of Toronto during Cannon's PhD candidature. Although Cannon and Jennings never met at that time, Mettrick's graduate student Christine Deane (who was to become Cannon's wife), had been put to work extracting 'little red worms' from sea urchins flown in from California, ably assisted by her friend Lester Cannon. Jennings was working on these worms with Mettrick in Toronto (Jennings & Mettrick, 1968; Mettrick & Jennings, 1969) which were umagillids, a group on which Cannon was to subsequently publish himself (Cannon, 1982, 1987, 1990).

In 1983 Cannon proceeded to England after meeting with Ax, Karling and Ball. He initially stayed with J.O. Young who had published on freshwater microturbellarians – one of the few researchers outside mainland Europe to do so. He then visited Ray Gibson in Liverpool – a Nemertean specialist who had borrowed material from the Queensland Museum collections during a visit prior to Cannon's appointment as Curator: Lower Invertebrates. Gibson was a student of Jennings' and drove Cannon over the Pennines to Leeds in order that they might meet. The fact that Jennings had been working in Toronto at the time Cannon and Deane were graduate students there, added to which they had both extracted the red worms on which he and Mettrick had been working, was an ideal ice-breaker of an introduction and Cannon and Jennings quickly established a rapport. Jennings (1971) had written the seminal review of parasitic and commensal turbellarians, and Cannon persuaded him to visit Queensland between October and November 1984. Cannon had found what he considered to be a variation on Jennings' thesis concerning lipid and glycogen storage in endoparasites. During Jennings' 1994 visit they resolved this question (Jennings & Cannon, 1985) working on old collections of Cannon's with histochemistry and some new collections from Europe brought out by Jennings. He stayed at International House on this visit and worked at the Department of Parasitology, University of Queensland. In addition to the physiology study, Jennings worked on *Bdellasimilis* (see Jennings, 1985) and initiated work on the ecology of temnocephalans which was finalised when Jennings returned on 17th October 1986 (Cannon & Jennings, 1987).

for 2 months' visit (QM Files, LI/U3a). During his 1986 visit, Jennings stayed with Cannon and his family and worked in Cannon's laboratory at the Queensland Museum. They visited Heron Island on the Great Barrier Reef and studied the respiratory haemoglobin in worms from sea cucumbers (Jennings & Cannon, 1987). They also visited Tasmania where they did some collecting assisted by Peter Young and found *Acholades* in the tube feet of starfish, which Jennings further explored (Jennings, 1989). As well, they visited the University of New England in Armidale where they demonstrated to Professor Klaus Rohde's assistant, Nikki Watson, an efficient extraction process of turbellarian worms. Watson subsequently visited Cannon's laboratory regularly in order to get expert training in extracting and recognising turbellarians.

From December 1988 to February 1990, correspondence between Cannon and Jennings was vigorous and it resulted in some further work on transmission electron microscopy (TEM) with the assistance of Jennings' EM technician, of the scales of a temnocephalan, *Notodactylus handschini* (Jennings, Cannon & Hick, 1992).

In February 1990 Cannon, supported by an official invitation from the Director of the Queensland Museum, Dr Alan Bartholomai, invited Jennings on a repeat visit to the Queensland Museum in November that year. Unable to come in 1990, Jennings accepted a subsequent invitation from the Director to visit in November 1991, in order to pursue research on turbellarian symbionts. In reiterating his welcome

of the previous year the Director added that 'Your collaboration with Dr Cannon over the past 6 to 7 years has been most productive' (QM File LI/U3b 1991). During Jennings' 1991 visit, he and Cannon spent considerable time observing and videoing the feeding habits of temnocephalans, but these observations were never published.

At the time of his 1991 visit, Jennings suggested to Cannon that they produce a review for the International Journal for Parasitology on '[...]a celebration of the Turbellaria as a major taxon of Platyhelminthes, mainly free-living but with species which have tried everything seen elsewhere in the phylum...there are very few parasitologists (*bona fide*) who know anything of the Turbellaria or publish on them[...]a theme for the Symposium in 1996?' (QM Files LI/U3b - 20 Nov 1991). This suggestion was, in fact, taken up by Cannon but at a later date. Jennings' wife Paula died in a tractor accident in 1994 and his grief and depression were extreme. Cannon then suggested that Jennings consider writing a review of events from the time of his 1971 review of parasitic and commensal turbellarians '25 years on' for the 1996 Turbellarian Conference (ISBT VIII) which he was convening in Brisbane. Jennings came and presented his review (Jennings, 1997) to wide acclaim.

Cannon availed himself of Jennings' broad knowledge of the 'Turbellaria' when compiling a submission to the Australian Research Council for funding to bring to the Queensland Museum from Russia, Dr Boris Joffe and his wife Dr Irina Solovei (QM Files LI/U3c, 3 February 1993).



FIG. 6. Dr Joe Jennings 1983 at Leeds University (left) and on podium 1996 at the Queensland Museum (right).

BORIS JOFFE AND IRINA SOLOVEI

Boris Joffe and his wife Irina Solovei (Fig. 7) came to work with Cannon in 1995 on an ARC funded study of the temnocephalan pharynx. Boris Joffe is an anatomist/morphologist/phylogenist with a strong background in worms who has published extensively on temnocephalans, both on the phylogeny of the group (Joffe, 1981, 1988) and in describing new records of scutariellids from Georgia, then part of the USSR (Joffe & Djanashvili, 1981). He was working at the Zoological Institute, Russian Academy of Sciences in St Petersburg, Russia. Dr Irina Solovei is a cytogeneticist and Cannon describes her as being '[...]a brilliant electron microscopist' whose expertise was essential in helping to elucidate relationships between temnocephalan worms. At that time she was employed at the Biological Research Institute at the University of St Petersburg.

Joffe and Cannon first met at the VI ISBT in Hirosaki, Japan in 1990, a conference where Cannon presented a paper on temnocephalans from *Cherax quadricarinatus* from Queensland (Cannon, 1991) and also showed a video of temnocephalans. The video was a great success and after the showing Joffe approached Cannon for a detailed discussion on temnocephalans. In subsequent correspondence Cannon suggested Joffe might consider coming to Queensland to work at the Queensland Museum if Cannon could attract funding from the Australian Research Council (ARC) and Joffe accepted. Cannon and Joffe again met in Turku, Finland, at the ISBT VII, proceedings of which were edited by Cannon (1995). Joffe was at the time of this conference, working in Baguna's laboratory in Barcelona, Spain, but he arranged for Cannon and his wife Christine to visit St Petersburg and stay with his own wife Irina Solovei in their apartment. In St Petersburg, Cannon again met Mamkaev as well as making the acquaintance of a frequent collaborator of Joffe's, Elena Kotikova. In 1993, Cannon successfully applied for an ARC grant specifically to bring Joffe and Solovei to Australia to undertake research with him on a project titled 'Taxonomy and Phylogenetic Significance of the Pharynx in the Turbellarian Flatworm Group, Temnocephalida'. The terms of the ARC grant included details of their engaging in studies of the pharynx structure of temnocephalan flatworms using light microscopy and electron microscopy to elucidate relationships. In this connection, Cannon took a course in transmission electron microscopy (TEM) at the University of Queensland in order

to have Irina Solovei work under his aegis. The TEM course produced a study on the glands of *Temnosewellia minor* (Cannon & Watson, 1996). The ARC grant also specified that collaboration would not only be with Cannon, but also with Dr Ian Whittington of the Department of Parasitology at the University of Queensland. In extending an official invitation to Drs Joffe and Solovei, the Director of the Queensland Museum stated: 'It is a privilege to have research scientists of your calibre coming to work in the Museum' (QM File LI/VI/2, 2/2/94).

Arriving for six months' stay in mid-1994 with their 9-year old daughter Sasha, Joffe and Solovei were respectively based at the Queensland Museum and the Centre for Microscopy and Microanalysis at the University of Queensland. Cannon's assistant at that time was Kim Sewell who was engaged in PhD studies on temnocephalans (Sewell, 1998), especially *Craspedella*. He also became involved with the temnocephalan work being done by Cannon, Joffe and Solovei, their collaboration leading to a publication on the organisation of the epidermal syncytial mosaic of *Diceratocephala boschmai* (Joffe, Solovei, Sewell & Cannon, 1995). Other Australian scientists to benefit from the Russian scientists' presence in Brisbane were Ian Whittington at the University of Queensland (Sewell & Whittington, 1995) and Klaus Rohde and Nikki Watson at the University of New England (Watson, Rohde & Sewell, 1995).

Cannon observed that during his six months at the Queensland Museum Joffe 'worked like a man driven' until Joffe's and Solovei's departure in December 1994. Collaboration between Cannon, Joffe and Solovei continued with numerous publications arising from their association (Cannon & Joffe, 2000; Joffe & Cannon, 1998 a, b, c; Joffe, Solovei, Watson & Cannon, 1997;



FIG. 7. Drs Boris Joffe and Irina Solovei.

Joffe, Solovei, Sewell & Cannon, 1995; Sluys, Joffe & Cannon, 1995).

Joffe attended ISBT VIII convened in Brisbane by Cannon in 1996 and here he presented a paper on a collaborative study of ultrastructural similarities between sense receptors in various turbellarians (Kornakova, Joffe, Solovei & Cannon, 1996). He and Cannon met again in July 1999 at the Platyhelminth Conference held in London, organised by Tim Littlewood and Rod Bray of the Natural History Museum for the Linnean Society of London. Cannon had been invited by the organisers to contribute a podium paper on the temnocephalans (Littlewood & Bray, pers. com., 27/10/97). Cannon and Joffe subsequently collaborated on a paper titled 'The Temnocephalida' (Cannon & Joffe, 2001) which Cannon presented at this conference.

Cannon considers that Joffe's interest in phylogeny, added to his feverish work pace and critical and incisive intellect, has contributed to a significant advance in the higher order understanding of the temnocephalans. He considers that his own efforts at the lower levels, in collaboration with Sewell, have provided much 'fodder for chewing' in respect of the lower order taxonomy (Cannon & Sewell, 1994, 1995; Sewell & Cannon, 1995, 1998a, b) and Cannon & Sewell (2001a) on *Dactylocephala* and also in preparation on *Temnosewellia*.

ERNEST SCHOCKAERT

An important delegate at the inaugural conference on the 'Turbellaria' in 1970 was Ernest Schockaert (Fig. 8), whom Cannon first met in 1984 at the ISBT IV in New Brunswick, Canada. Schockaert, a Belgian, was born in the then Belgian Congo. He received his education in Europe and undertook PhD studies with Tor Karling in Stockholm. He also spent some months with Papi in Italy. At the time of their first meeting, Schockaert was Professor of Zoology at Limburgs Universitair Centrum in Diepenbeek, Belgium, where he had convened the III ISBT. Here he gathered a comprehensive library of works and drawings on turbellarians. These comprise a significant resource which Cannon believes should be published. Schockaert is an acknowledged international expert on the Kalyptorhynchia.

Two graduate students of Schockaert's whom Cannon met in 1984 were Els Martens and Paul Martens (unrelated), the latter a future collaborator of Marco Curini-Galletti (Fig 9) (*vide infra*).

Martens and Schockaert produced a significant review of the importance of turbellarians in the marine meiobenthos (Martens & Schockaert, 1986).

Cannon and Schockaert renewed their acquaintance at the ISBT VI in Hiroasaki, Japan, in 1990 and subsequently in 1993 in Åbo/Turku, Finland, at the ISBT VII, when Schockaert invited Cannon to return with him to Diepenbeek and to visit the University. Later, Schockaert was to sponsor Nikki Watson from the University of New England in 1995 to work with him in Belgium on electron microscope studies of turbellarians.

Schockaert has conducted collecting and research along the East African coast, in Mexico and in Europe. In 1996 he attended the ISBT VIII in Brisbane and took part in the Stradbroke Island workshop. In 1997 he returned to Queensland for two months at Cannon's invitation (QM Files LIU-1-4, 12 May 1997), working again on Stradbroke Island but also at Townsville, whence he proceeded into New South Wales to work in Sydney and at Arrawarra, Coffs Harbour. Cannon requested that Schockaert not only impart some of his knowledge of the kalyptorhynchs to Australian scientists but also to work on the Australian fauna and contribute to the Queensland Museum turbellarian collections — the only such collections of any note in Australia. Cannon hoped that by studying the Australian kalyptorhynchs first hand, Schockaert would be able to make a useful



FIG. 8. Dr Ernest Schockaert.

contribution to the turbellarian chapter of the projected publication *Fauna of Australia*. Volume 9: Worms, to be published by the Australian Biological Resource Study (ABRS). Australian researchers' knowledge of the kalyptorhynchs was scanty, though they knew the Australian fauna to be rich. Following his two-month visit, Schockaert provided Cannon with an extensive list running to three full pages of turbellarians he had encountered — most of them new.

Having been able to stimulate some interest in many turbellarian groups, one of the largest and most neglected are the freshwater microturbellarians of which the Typhloplanidae is a major family.

MARCO CURINI-GALLETTI

Cannon first met Marco Curini-Galletti in Canada in 1984 at the IVth Symposium. Now Associate Professor at the Instituto di Zoologia, Università di Sassari (Sardinia), Italy, Curini-Galletti (Fig. 9) in 1984 was working in Pisa where he had graduated. Although he had done work on polyclad predators of oysters, he had recently teamed up with Paul Martens, Schockaert's graduate student. Curini-Galletti and Martens collaborated on studying Proseriates, Martens' emphasis being morphology to which Curini-Galletti added karyology, an area of especial expertise from Pisa since it had been the interest of Mario Benazzi.



FIG. 9. Dr Marco Curini-Galletti, Brisbane, 1996 (Dr Vittorio Gremigni behind).

Cannon and Curini-Galletti were to meet again at the train station in Hiroasaki, Japan, at the time of the ISBT VI in 1990. Curini-Galletti mentioned he had been in Australia collecting specimens along the east coast and also from near Darwin (Martens & Curini-Galletti, 1989; Curini-Galletti & Martens, 1991). Admonishing him for not getting in touch, Cannon mooted the possibility of his coming to Queensland to collaboratively study marine proseriate meiobenthos. After further correspondence, Cannon in early 1992 applied for an ARC grant which was awarded for the years 1993-1995. Curini-Galletti made two 2-3 month trips to Australia, first in 1993 and again in 1995. His visits were productive and included collecting in Cairns, on Green Island and Heron Island all in Queensland (Curini-Galletti & Cannon, 1995, 1996, 1997); in Tasmania and at Arrawarra Station, Coffs Harbour in New South Wales.

Following attendance at the Workshop on Stradbroke Island prior to ISBT VIII, Curini-Galletti handed Cannon a list of more than 100 new species he had found within 35 genera (15 of which were new) belonging to all families of Proseriates occurring in Australia.

Arising from Cannon's interaction with Anno Faubel in the 1980s (see above), Faubel subsequently approached Cannon to provide a support base for him at the Queensland Museum.

ANNO FAUBEL

In 1993, Anno Faubel (Fig. 10) brought with him to the Queensland Museum a nematologist, Dietrich Blome, to work on Australian fauna. They spent two months in Queensland, resulting in a collaborative paper on Australian meiofauna (Faubel, Blome & Cannon, 1994). They also contacted their German colleague Klaus Rohde at the University of New England in Armidale, such collaboration leading to a publication (Faubel, Rohde & Watson, 1994). Returning to Australia in 1998, Faubel and Blome worked mainly from the University of Queensland since facilities for 'wet work' suited them more in the School of Marine Sciences there.

Faubel erected a proseriate genus *Cannonia* and sub-family Cannoninae in Cannon's honour (Faubel & Rohde, 1998).

REINHARDT KRISTENSEN

Reinhardt Kristensen (Fig. 11) is Professor of Zoology at the University of Copenhagen in Denmark. He has specialised with work

on meiofaunal worms and other minor phyla (Eibye-Jacobsen & Kristensen, 1994; Higgins & Kristensen, 1988a,b; Kristensen & Higgins, 1991; Kristensen & Norrevang, 1978; Kristensen 1982, 1983, 1992). He has the singular distinction of having described two new phyla during the 20th century (Franzen & Kristensen, 1984; Funch & Kristensen, 1995). One group, Cycliophora, is parasitic, but the Loricifera are tiny interstitial worms related to gastrotrichs and echinorhynchids (Shirayama & Kristensen, 1988; Winnepenninck, Bekeljaou & Kristensen, 1998). He also published on these with Robert Higgins of the Smithsonian Institute and it was Higgins who co-edited the book on meiofauna in which Cannon's paper on meiofaunal turbellaria had appeared (Cannon & Faubel, 1988). Kristensen was thus familiar with Cannon's own work in this connection.

International networking among scientists has always been of the utmost importance. A further example of networking amongst Cannon's colleagues was contact being made by Niel Bruce in 1994. Bruce was at that time Associate Professor of Zoology at the Zoological Museum in the University of Copenhagen and he requested Cannon to consider providing accommodation at the Queensland Museum for Reinhardt Kristensen's '[...] sabbatical year in 1995' (QM File LI/VI/2, 1994).

When Niel Bruce contacted Cannon it was to advise that Kristensen was wanting to take a 12-month sabbatical leave in Australia studying warm water meiofauna, and that he had quizzed Bruce on the appropriate Australian institution in which to work. Bruce had suggested the Queensland Museum since Cannon was the only Australian scientist involved with warm water meiofauna (QM File LI/VI/2, 1994). Cannon immediately contacted Bruce (QM Files LI/VI/2, 1994) with the reassurance that Kristensen was welcome to work at the Queensland Museum, adding that he himself had been '[...] a little more involved with meiofauna over the past six months, working with Marco Curini-Galletti'. In Kristensen's direct response to Cannon (QM Files, LI/VI/1, 1994), he advised he had samples from the Coral Sea and from Brisbane but lacked sub-tidal samples from quartz sand and shell gravel. He added he hoped to arrive in Brisbane on 1 August 1995.

During his one year sabbatical at the Queensland Museum, Kristensen concentrated on tardigrades in marine and fresh waters (Kristensen & Hallas, 1980; Kristensen & Higgins, 1984). Cannon capitalised on Kristensen's presence by availing a young scientist, Glen Anderson, of his expertise. He employed Anderson to work alongside Kristensen for six months studying marine meiofauna. Anderson found and described several species which were presented as a poster at ISBT



FIG. 10. Dr Anno Faubel.



FIG. 11. Prof Reinhardt Kristensen, Brisbane, 1996.

VIII (Anderson & Cannon, 1996), but he seemed reluctant to finish off and Cannon handed him over to visiting scientist Schockaert (*vide supra*). Anderson is currently a veterinary protozoologist with the Queensland Department of Primary Industry.

Kristensen returned to Queensland briefly to attend ISBT VIII in 1996 to present a paper on another unique group, the Micrognathozoa (Kristensen & Funch, 1996, 2000).

ULF JONDELIUS

Ulf Jondelius (Fig. 12) had been a student of Jan Hendelberg from Göteborg, Sweden. Jondelius specialised in cladistic studies of turbellarian symbionts. He took over curatorship of the invertebrate collections at the Swedish Museum of Natural History in Stockholm in 1992, a position previously held by Tor Karling, but is now at the University of Uppsala. Cannon and Jondelius had first met in Hiroasaki, Japan in 1990 and subsequently at ISBT VII in Åbo/Turku, Finland, in 1993. Prior to this conference, Jondelius invited Cannon and his wife Christine to visit with him and his wife Irina in Stockholm.

Jondelius had visited Australia independently and examined collections at the Queensland Museum in addition to making some collections of meiofaunal worms and erecting a new genus of Prolecithophora.

In 1995, Cannon wrote to Jondelius (QM Files LI/VI/2, 1995) to invite him to Australia in 1996 to participate in research on turbellarian systematics and biology at the Queensland Museum where there was an active research group in this field. He advised the Museum had good facilities for light microscopy and scanning electron microscopy, and that the University of Queensland provided them access to transmission electron microscopy and fluorescent microscopy. He also mentioned that the Australian Biological Resources Study (ABRS), a nationally administered project to document Australia's biodiversity, anticipated preparing manuscripts within two to three years on the worm groups. He furthermore stated that Jondelius' interests in freshwater microturbellarians, as well as in some groups of marine interstitial symbiotic worms, was of particular relevance at that time.

Jondelius was unable to come for the 6-month period Cannon had hoped, but in 1996 he attended the Stradbroke Island Workshop prior to ISBT VIII and subsequently worked at Heron Island. Cannon maintained good relations with him and in April 2000, has corresponded with one of his students about echinoderm symbionts.

SABINE DITTMANN

Cannon first met Sabine Dittmann (Fig. 13) in 1983 on the Island of Sylt where she was carrying out doctoral studies with Peter Ax's group on



FIG. 12. Dr Ulf Jondelius with Dr Tom Artois, Heron I., 1996.



FIG. 13. Dr Sabine Dittmann, Brisbane, 1996.

the ecology of meiofauna. Cannon subsequently encouraged her to apply to the Australian Institute of Marine Science at Townsville for a post-doctoral scholarship, and she spent two years there working on interstitial ecology (Dittmann, 1991, 1994, 1995, 1996, 1998). She collected extensively during that time, leaving her worms with Leigh Winsor at James Cook University of North Queensland. This collection needs taxonomic treatment and awaits description.

Dittmann attended ISBT VIII in 1996 and again worked at Stradbroke Island. Until recently, she has worked as a research co-ordinator for Tropical Marine Ecology in Bremen, supervising the studies of Blome (Faubel's colleague). She is now at Flinders University, Adelaide.

RONALD SLUYS

Cannon first met Sluys (Fig. 14) in Amsterdam when visiting Ian Ball in 1983. Now an acknowledged world leader in 'Maricola' (marine worms) (Sluys, 1989), Sluys worked in Queensland briefly in 1996 around the time of ISBT VIII and is attempting to get renewed funding from ABRS to return to Queensland. Sluys and Cannon have published two papers together (Sluys & Cannon, 1990; Sluys, Joffé & Cannon, 1995). Sluys now has Ian Ball's collections of *Paludicola* (freshwater planarians) and will be studying these.

CRISTINA DAMBORENEA

A temnocephalan worker who had not previously attended a turbellarian conference but who was a delegate at ISBT VIII, was Cristina Damborenea. Damborenea (Fig. 15) is a scientist in the Department of Invertebrate Zoology at the Museum of Natural History in La Plata, Argentina. She had published on temnocephalans prior to attending



FIG. 14. Dr Ron Sluys (centre) with Drs Jennings and Boaden, 1996, at the 8th ISBT in Brisbane.



FIG. 15. Dr Cristina Damborenea at the Buenos Aires Zoo 1998.

ISBT VIII in 1996, and donated specimens to the Queensland Museum of *Temnocephala iheringi* Haswell 1893, subsequent to participating in the Stradbroke Island Workshop (QM File LI M-1, 1996).

During his 1998 trip to the Americas on the Colliver Scholarship, Cannon worked with Damborenea in Argentina. Arising from this was a paper which reviews all the *Temnocephala* of the Neotropics and recognises that this genus is restricted to that region. They described a new genus, *Temnosewellia*, for Australian worms formerly placed in the genus *Temnocephala* (Damborenea & Cannon, 2000).

AUSTRALIAN TURBELLARIAN COLLEAGUES INFLUENCED BY CANNON

As reported in the foregoing pages, Cannon, over two decades, attracted to the Queensland Museum to work with him, a number of international scientists who are experts in their fields. He states that it is difficult to know how his own interest and involvement in turbellarians has influenced other scientists in Australia, but suggests they are few in number.

KLAUS ROHDE

Recently retired as Professor of Zoology at the University of New England in Armidale, Rohde (Fig. 16) shared a room with Cannon in the Department of Parasitology at the



FIG. 16. Drs Robert Ogren and Klaus Rohde, 1996.

University of Queensland during 1971-1972 when Cannon was a Queen's Fellow and Rohde a University of Queensland Fellow. A graduate from Germany, Rohde had spent several years in Malaya before coming to Australia as an established and distinguished scientist. Becoming Director of Heron Island Research Station in the period 1974-1976, Rohde subsequently took up his appointment in Armidale shortly before Cannon joined the Queensland Museum.

In pursuing with vigour his interest in the origins of parasitic flatworms via studies first in ultrastructure and then in molecular work, Rohde during the 1980s approached Cannon for help with supply and identification of turbellarians. Indeed, in 1986 Jennings and Cannon visited Armidale to demonstrate turbellarian extraction techniques to Rohde's research assistant, Nikki Watson (*vide supra*). Several publications resulted from these contacts (Rohde, Cannon & Watson, 1987, 1988a, b, c; Rohde, Watson & Cannon, 1987, 1988a, b, c).

Rohde has gained international distinction from his work on the origins and phylogeny of the parasitic plathyelminthes whilst also gaining distinction as a theoretical parasite ecologist

NIKKI WATSON

For many years Rohde's research assistant, Watson (Fig. 17) has established an independent reputation for research on ultra-structure of sperm

of turbellarians. She and Cannon have subsequently collaborated on work on *Temnosewellia minor* (Cannon & Watson, 1996).

LESLIE NEWMAN

After graduating in Canada, Leslie Newman (Fig. 18) undertook doctoral studies on pelagic molluscs with Dr Jack Greenwood in the Department of Zoology at the University of Queensland. As a keen SCUBA diver and underwater photographer with considerable knowledge of molluscs including nudibranchs, she was intrigued to discover that many of the 'nudibranchs' were gloriously coloured and patterned marine worms – polyclad turbellarians. Dr R.J.G. Lester in the Department of Parasitology at the University of Queensland did some parasite work on Newman's molluscs (Lester & Newman, 1986) and told her of Cannon's interests in turbellarians.

Whilst she was Scientific Research Officer at Heron Island Research Station in the absence of the Director, Newman wanted a six-month study project and Cannon suggested she carry out a photographic and specimen collection of the polyclad turbellarians, which were a little known group in Australia although seemingly more common than thought. Notoriously difficult to fix, the idea of taking colour photographs of these beautiful worms appealed to Newman, who made an impressive collection. When Cannon attended ISBT VII at Åbo Akademi, Turku, Finland in 1993, he presented a six-minute video as an adjunct to Newman & Cannon's (1993) poster of living tropical polyclads. The poster and video were especially warmly received because of the stunning colours of those beautiful worms.

Cannon successfully applied for an Australian Research Council (ARC) post-doctoral research grant to enable Newman to work with him during the period 1993-1995. Publications arising from this period are important. Their first paper (Newman, Cannon & Govan, 1993), in addition to recording a new species of polyclad worm, reported on the discovery of pests of pearl oysters in culture in the Solomon Islands. They subsequently reported on a mimic of a toxic nudibranch (Newman, Cannon & Brunckhorst, 1994), followed by an account of biodiversity of the worms (Newman & Cannon, 1994a), but their big paper (Newman & Cannon, 1994b) reported on the very speciose group Pseudocerotidae in Australia and Papua-New Guinea. This set the scene for a string of subsequent papers which greatly increases the world's understanding



FIG. 17. Dr Nikki Watson (centre) with Drs David Blair and Joe Jennings at Brisbane Conference 1996.



FIG. 18. Drs Lester Cannon & Leslie Newman (2002).

of these worms, with several new genera and many new species being described (Newman & Cannon, 1995b, 1996a, b, 1997a, b, 1998, 2000).

As observed earlier, polyclad turbellarians are notoriously difficult to preserve. Newman and Cannon came up with a fixation technique based upon a fixative of Leigh Winsor's and a fixation procedure developed by Newman whilst in Madang, Papua-New Guinea. This technique leaves the worms flat and with their pattern and even some of their colour intact (Newman & Cannon, 1995a).

Newman and Cannon have also collaborated on popular articles (Newman & Cannon, 1994c; Cannon & Newman, 1996) in addition to being editor and picture editor of the CD-ROM of the Great Barrier Reef (Cannon & Newman, 1994) based largely on Exploring Australia's Great Barrier Reef (Cannon & Goycn, 1989) and on Newman's photographs.

Cannon and Newman's collaboration was ongoing and a collection of polyclad worms made primarily by Newman is held at the Queensland Museum. It is the best such collection in the world. Cannon and Newman have produced a book on polyclads, 'Fabulous Flatworms', which was shortlisted for the Australian Museum's Eureka prize in 2003. They subsequently developed a CD-ROM guide which won the Linnean Society of NSW's Whitley award in 2005, both were published by the CSIRO (Newman & Cannon, 2003, 2005). Newman was awarded a Smithsonian Fellowship in 1997-1998 and during her tenure developed an association with Marian Litvaitis with whom she pursued studies of polyclad systematics using molecular markers.

Newman and her late husband, Dr Andrew Flowers, who was a marine chemist, returned to Queensland from USA in 1999 when Flowers took up a position at the University of the Sunshine Coast at Maroochydore. In May 2000, they moved to the Southern Cross University at Lismore, New South Wales. She has subsequently served as Curator of Marine Biology at the Auckland Museum, New Zealand.

POST-GRADUATE STUDENTS

The nature of Cannon's duties as Museum Curator did not provide him many opportunities to train graduate students, the two exceptions being Kim Sewell and Kylie Dwine.

KIM SEWELL

Kim Sewell (Fig. 19) became Cannon's technical assistant in 1989. Sewell had been employed by the Department of Parasitology, University of Queensland, between 1977 and 1989 at their Veterinary Farm Precinct at Pinjarra Hills. He left the position of Scientific Officer in the Marine Parasitology Section at that site, to take up appointment as technical officer with the Senior Curator: Worms at the Queensland Museum. Sewell studied part-time towards a Bachelor of Science degree whilst working for the Department of Parasitology and was awarded the degree in 1985 with majors in Parasitology and Zoology. Since he had been Scientific Assistant in the Marine Parasitology section from 1984, Sewell elected to undertake a part-time Honours project on parasites of fish. He was awarded a First Class Honours degree in 1988. This earned him promotion to the position of Scientific Officer in the same year,



FIG. 19. Dr Kim Sewell, Queensland Museum, circa 1999.

a position he held until joining Cannon at the Queensland Museum in 1989.

Although hoping to appoint Sewell as a professional officer commensurate with his qualifications and experience, Cannon was unable to appoint him to anything other than a technical officer's position – a state of affairs which rankled with them both. Sewell was of enormous benefit to Cannon during the period when the parasitology collections burgeoned. In addition to integrating the collections with those existing at the Queensland Museum, Sewell became main manager of the databases for these collections. Indeed, he ably assisted Cannon in establishing the database 'ASPIC' which records details of parasitology collections throughout Australian institutions (Angus, Cannon & Adlard 2007). Additionally, acquisition of the IRCAH from Canada necessitated integration of that extensive collection of 120,000 specimen records to those of the Queensland Museum, and this was proficiently executed by Sewell.

Whilst at the Queensland Museum, Sewell enrolled as a part-time PhD candidate in the Department of Parasitology and the Department of Anatomical Sciences at the University of Queensland, on the study of temnocephalans.

His supervisor in parasitology was Dr Ian Whittington, a past student of Graham Kearn, the eminent monogenean authority whom Cannon had first met in Toronto and who subsequently worked in Cannon's laboratory when he was a Queen's Fellow in Marine Science at the Department of Parasitology.

Cannon and Sewell jointly explored temnocephalans. Beginning with ABRIS-funded work, they proceeded through eastern Queensland via camper van, thence through Victoria and New South Wales and back to Queensland using hire cars and motels. Finally, they visited Tasmania and Western Australia. Initially using a special box constructed as a travelling laboratory, they subsequently found it more convenient to utilise the light and water sources in their various motels. Their modus operandi in locating temnocephalans was to first visit Museums in the various areas, inspect their crayfish specimens and note species and location sources. This enabled them to retrace possible tracts to intercept the most species available. They set traps — mostly for an hour or so, but sometimes overnight — then turned rocks or scoured creek banks for crayfish holes. Evenings were spent dissecting and fixing worms.

During his studies, Sewell was benefited greatly by the presence of Boris Joffe at the Queensland Museum as a visiting scientist. This provided much stimulating intellectual debate and curiosity about temnocephalans. Cannon considers that his and Sewell's work both separately and in collaboration, has made and continues to make significant advances in our knowledge of temnocephalan worms. Publications arising from their studies include Cannon & Sewell (1994, 1995, 2001b), Sewell & Cannon (1994, 1998a, b), Joffe, Solovei, Sewell & Cannon (1995), Sewell & Whittington (1995), Watson, Rohde & Sewell (1995).

Awarded his PhD in 1998 and with no likelihood of having his position at the Queensland Museum upgraded to Curator, Sewell decided to pursue a career in teaching. Accordingly, he enrolled in studies towards a Graduate Diploma of Education in the same year. He then taught electron microscopy at the University of Queensland, but returned temporarily in 2002 to spend one year on an ARC funded study to Blair, Cannon, Littlewood and Lawler. This was to study, for evidence of co-evolution, the ancient, strictly invertebrate symbiosis of temnocephalans and crayfish. Blair is a parasitologist and Associate Prof at James

Cook University, Townsville, Littlewood is a molecular phylogenist and Wellcome Fellow at the Museum of Natural History, London, and Lawler is a crayfish phylogenist and Lecturer at La Trobe University, Wodonga. The major taxonomic component of that research has now been published (Sewell, Cannon & Blair, 2006)

KYLIE DWINE

It had long been Cannon's wish to investigate freshwater microturbellarians in Australia and he secured an ABRs grant for a graduate student to undertake such a project. A First Class Honours student in parasitology, Kylie Dwine volunteered to work with Cannon at the Queensland Museum and he invited her to undertake PhD studies on this project in 1998. With a visiting academic from the United States, a small paper resulted on what work she had carried out (Hartenstein & Dwine, 2000). Kylie resigned after twelve months to leave research and pursue other interests. Cannon once more attracted ABRs funding to investigate freshwater and marine microturbellarians within the Typhloplanida, the predominant freshwater rhabdocoel group.

RICK HOCHBERG

Cannon's successful ABRs grant led to the appointment of Rick Hochberg (Fig. 20), a student of the University of New Hampshire who completed his PhD research on meiofaunal *Gastroticha* with Marian Litvaitis. Cannon had



FIG. 20. Dr Rick Hochberg.

met Marian Litvaitis at the 4th Symposium in New Brunswick in 1984 when, as Marianne Klausner, she was a student of the Acoela. Hochberg brought a wealth of meiofaunal experience, and though he was not expert with the Typhloplanoida, his experience and commitment ensured success. Hochberg subsequently became a Smithsonian Fellow and now teaches at the University of Connecticut (Lowell) in the USA.

QUEENSLAND CENTRE OF EXPERTISE ON THE 'TURBELLARIA'

This paper has reported how Cannon (Fig. 18) has availed Australia of the expertise of international scholars who are specialists in knowledge of the 'Turbellaria', both by securing funding grants to cover living expenses in Queensland for some scientists to visit for a period of months, or by providing a support base at the Queensland Museum for others. The collaborations between these visiting scientists, Cannon, and other Australian flatworm scholars, have resulted in important publications which greatly advanced the knowledge of the Turbellaria as a group. Additionally, the Queensland Museum collections have benefited from having specimens which have been garnered from various sites in Queensland and elsewhere in Australia, donated by these visitors.

Cannon has, alone or with others, described many new taxa (Appendix I) and has been honoured with numerous patronyms (Appendix II).

In recognition of Cannon's contributions in bringing focus onto the Queensland Museum as an important research centre for turbellarian studies, as well as his work with building up the Parasitology Collections (see Angus, Cannon & Adlard, 2007), the Queensland Museum in 1998 awarded him the Colliver Scholarship to enable him to travel throughout the Americas to study and report on Museum curation methods. He was honoured with presentation of the Queensland Museum Medal in 2003

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- Temnosewellia* Damoborenea & Cannon, 2000
- Tythyoceros* Newman & Cannon, 1997
- Zygopella* Cannon & Sewell, 1995

New Species:

Acanthopsuedomonocelis mirabilis Curini-Galletti & Cannon, 1995

Achenella cougal Cannon, 1993

Achenella sathonota Cannon, 1993

Anoplodium heronensis Cannon, 1990

Anoplodium leigli Cannon, 1990

Apidioplana apluda Cannon, 1990

Archimonocelis medusa Curini-Galletti & Cannon, 1997

Bradburia australiensis Faubel, Blome & Cannon, 1994

Bulaceros porcellanus Newman & Cannon, 1996

Caryospora dendrolaphis Cannon & Rzepcyk, 1974

Caryospora demansiae Cannon, 1967

Cleistogamia heronensis Cannon, 1982

Cleistogamia longicirrus Cannon, 1982

Cleistogamia palli Cannon, 1982

Cleistogamia pulchra Cannon, 1982

Cleistogamia pyriformis Cannon, 1982

Craspedella pedum Cannon & Sewell, 1995

Craspedella gracilis Cannon & Sewell, 1995

Craspedella shorti Cannon & Sewell, 1995

Craspedella yabba Cannon & Sewell, 1995

Craspedella simulator Cannon & Sewell, 1995

Craspedella bribiensis Sewell & Cannon, 1998

Craspedella joffei Sewell & Cannon, 1998

Craspedella cooranensis Sewell & Cannon, 1998

Decadidymus gulosus Cannon, 1991

Dunwichia arenosa Faubel, Blome & Cannon

Eimeria ablephari Cannon, 1967

Eimeria egerniae Cannon, 1967

Eimeria gehyrae Cannon, 1967

Eimeria lampropholidus Cannon, 1967

Eimeria leiopismatis Cannon, 1967

Gelasinella powellorum Sewell & Cannon, 1998

Gieysztoria queenslandica Hochberg & Cannon, 2001

Hysterothylacium scomberoidei Bruce & Cannon, 1989

Isospora ablephari Cannon, 1967

Isospora amphiboluri Cannon, 1967

Isospora egerniae Cannon, 1967

Jugatovaria polynesianana Sluys & Cannon, 1989

Macrostomum australiense Faubel, Blome & Cannon, 1994

Maricostula cenatica Bruce & Cannon, 1989

Maricostula histiophori Bruce & Cannon, 1989

APPENDIX I

NEW TAXA DESCRIBED BY L.R.G. CANNON

New Families:

Diceratocephalidae Joffe, Cannon & Schockaert, 1998

New Sub-families:

Craspedellinae Cannon & Sewell, 1995

New Genera:

Acanthopsuedomonocelis Curini-Galletti & Cannon, 1995

Achenella Cannon, 1993

Bradburia Faubel Blome & Cannon, 1994

Bulaceros Newman & Cannon, 1996

Decadidymus Cannon, 1991

Dunwichia Faubel Blome & Cannon, 1994

Gelasinella Sewell & Cannon, 1998

Heptacraspedella Cannon & Sewell, 1995

Maricostula Bruce & Cannon, 1989

Maritigrella Newman & Cannon, 2000

Paranotothrix Cannon, 1982

Seritia Cannon, 1982

- Maricostula makairi* Bruce & Cannon, 1989
Maricostula tetrapteri Bruce & Cannon, 1989
Maritigrella eschara Newman & Cannon, 2000
Maritigrella marygasonae Newman & Cannon, 2000
Maritigrella ocellata Newman & Cannon, 2000
Maritigrella stellata Newman & Cannon, 2000
Maritigrella virgulata Newman & Cannon, 2000
Minona australis Curini-Galletti & Cannon, 1996
Minona concharum Curini-Galletti & Cannon, 1996
Minona heronensis Curini-Galletti & Cannon, 1996
Minona proculvaginata Curini-Galletti & Cannon, 1996
Monocelis beata Curini-Galletti & Cannon, 1996
Monocelis corallicola Curini-Galletti & Cannon, 1996
Monocelis macrobulbus Curini-Galletti & Cannon, 1996
Monocelis nexilis Curini-Galletti & Cannon, 1996
Monocelis rupisrubrae Curini-Galletti & Cannon, 1996
Monocystella epibatis Cannon & Jennings, 1988
Myoramyxa pardalota Newman & Cannon, 1997
Notoplana comes Cannon & Grygier, 1991
Paranotothrix queenslandensis Cannon, 1982
Pseudobiceros apricus Newman & Cannon, 1994
Pseudobiceros brogani Newman & Cannon, 1997
Pseudobiceros damawan Newman & Cannon, 1994
Pseudobiceros flavocanthus Newman & Cannon, 1994
Pseudobiceros flowersi Newman & Cannon, 1997
Pseudobiceros fulgor Newman & Cannon, 1994
Pseudobiceros gloriosus Newman & Cannon, 1994
Pseudobiceros hymanae Newman & Cannon, 1997
Pseudobiceros kryptos Newman & Cannon, 1997
Pseudobiceros mikros Newman & Cannon, 1997
Pseudobiceros murinus Newman & Cannon, 1997
Pseudobiceros periculosus Newman & Cannon, 1994
Pseudobiceros sharroni Newman & Cannon, 1997
Pseudobiceros stellae Newman & Cannon, 1994
Pseudobiceros uniarborensis Newman & Cannon, 1994
Pseudoceros bolool Newman & Cannon, 1994
Pseudoceros cruentus Newman & Cannon, 1998
Pseudoceros depiliktatub Newman & Cannon, 1994
Pseudoceros felis Newman & Cannon, 1994
Pseudoceros goslineri Newman & Cannon, 1994
Pseudoceros heronensis Newman & Cannon, 1994
Pseudoceros imperatus Newman & Cannon, 1998
Pseudoceroa imitatus Newman, Cannon & Brunckhorst, 1994
Pseudoceros irretitus Newman & Cannon, 1998
Pseudoceros jebborum Newman & Cannon, 1994
Pseudoceros josei Newman & Cannon, 1998
Pseudoceros kylie Newman & Cannon, 1998
Pseudoceros lactolinbus Newman & Cannon, 1998
Pseudoceros laingensis Newman & Cannon, 1998
Pseudoceros laticlavus Newman & Cannon, 1994
Pseudoceros lindae Newman & Cannon, 1994
Pseudoceros monostichos Newman & Cannon, 1994
Pseudoceros ouini Newman & Cannon, 1994
Pseudoceros periaurantius Newman & Cannon, 1994
Pseudoceros peripurpureus Newman & Cannon, 1994
Pseudoceros prudhoei Newman & Cannon, 1994
Pseudoceros rubronanus Newman & Cannon, 1998
Pseudoceros sapphirinus Newman & Cannon, 1994
Pseudoceros scintillatus Newman & Cannon, 1994
Pseudoceros scriptus Newman & Cannon, 1998
Pseudoceros stimpsoni Newman & Cannon, 1998
Pseudoceros verecundus Newman & Cannon, 1994
Pseudomonocelis schockaerti Curini-Galletti & Cannon, 1995
Pterastericola australis Cannon, 1986
Pterastericola ramosa Cannon, 1986
Pterastericola sprengi Cannon, 1986
Pterastericola vivipara Cannon, 1978
Stylochus matatasi Newman, Cannon & Govan, 1993
Temnocephala athertonensis Cannon, 1993
Temnocephala butlerae Cannon, 1993
Temnocephala improcera Cannon, 1993
Temnocephala minuta Cannon, 1993
Temnocephala neqae Cannon, 1993
Temnocephala queenslandensis Cannon, 1993
Tennohaswellia alpina Sewell, Cannon & Blair, 2006
Tennohaswellia brevumbella Sewell, Cannon & Blair, 2006
Tennohaswellia capricornia Sewell, Cannon & Blair, 2006
Tennohaswellia cornu Sewell, Cannon & Blair, 2006
Tennohaswellia crotalum Sewell, Cannon & Blair, 2006
Tennohaswellia munifica Sewell, Cannon & Blair, 2006
Tennohaswellia pearsoni Sewell, Cannon & Blair, 2006
Tennohaswellia pugna Cannon, 1993 [junior subjective synonym of *Tennohaswellia comes* (Haswell, 1893), see Sewell, Cannon & Blair, 2006]
Tennohaswellia subulata Sewell, Cannon & Blair, 2006
Tennohaswellia tetrica Cannon, 1993 [junior subjective synonym of *Tennohaswellia simulator* (Haswell, 1924), see Sewell, Cannon & Blair, 2006]
Tennohaswellia umbella Sewell, Cannon & Blair, 2006
Tennohaswellia verruca Sewell, Cannon & Blair, 2006
Tennosewellia acicularis Sewell, Cannon & Blair, 2006
Tennosewellia acirra Cannon & Sewell, 2001

- Temnosewellia alba* Sewell, Cannon & Blair, 2006
Temnosewellia albata Sewell, Cannon & Blair, 2006
Temnosewellia aplyodes Sewell, Cannon & Blair, 2006
Temnosewellia apiculatus Sewell, Cannon & Blair, 2006
Temnosewellia arga Sewell, Cannon & Blair, 2006
Temnosewellia argeta Sewell, Cannon & Blair, 2006
Temnosewellia argilla Sewell, Cannon & Blair, 2006
Temnosewellia aspinosa Sewell, Cannon & Blair, 2006
Temnosewellia aspra Sewell, Cannon & Blair, 2006
Temnosewellia bacrio Sewell, Cannon & Blair, 2006
Temnosewellia bacrionculus Sewell, Cannon & Blair, 2006
Temnosewellia batiola Sewell, Cannon & Blair, 2006
Temnosewellia belone Sewell, Cannon & Blair, 2006
Temnosewellia caliculus Sewell, Cannon & Blair, 2006
Temnosewellia cestus Sewell, Cannon & Blair, 2006
Temnosewellia christineae Cannon & Sewell, 2001
Temnosewellia conythus Sewell, Cannon & Blair, 2006
Temnosewellia coughrani Sewell, Cannon & Blair, 2006
Temnosewellia cypellum Sewell, Cannon & Blair, 2006
Temnosewellia fax Sewell, Cannon & Blair, 2006
Temnosewellia flammula Sewell, Cannon & Blair, 2006
Temnosewellia gingrina Sewell, Cannon & Blair, 2006
Temnosewellia gracilis Sewell, Cannon & Blair, 2006
Temnosewellia keras Sewell, Cannon & Blair, 2006
Temnosewellia maculata Sewell, Cannon & Blair, 2006
Temnosewellia magna Sewell, Cannon & Blair, 2006
Temnosewellia maxima Sewell, Cannon & Blair, 2006
Temnosewellia minima Sewell, Cannon & Blair, 2006
Temnosewellia muscalingulata Sewell, Cannon & Blair, 2006
Temnosewellia phantasmella Cannon & Sewell, 2001
Temnosewellia possibilitas Sewell, Cannon & Blair, 2006
Temnosewellia punctata Cannon & Sewell, 2001
Temnosewellia unguiculus Sewell, Cannon & Blair, 2006
Tythyoceros lizardensis Newman & Cannon, 1996
Tythyoceros nocturnus Newman & Cannon, 1996
Umagilla karlingi Cannon, 1987
Umagilla pacifica Cannon, 1987
Wahlia stichopi Cannon, 1982
Zygopella pista Cannon & Sewell, 1995
Zygopella deimata Cannon & Sewell, 1995
Zygopella stenota Cannon & Sewell, 1995
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APPENDIX II

PATRONYMS OF L.R.G. CANNON

Protozoa

Isospora cannoni Finkelmann & Paperna, 1994

Urosporidium cannoni Anderson, Newman, & Lester, 1993.

Platyhelminths

Syndesmis cannoni Jondelius, 1996 (Turbellarian)

Polystylifera cannoni Curini-Galletti, 1998 (Turbellarian)

Cannoninae Faubel & Rohde, 1998 (Turbellarian: as subfamily of F. Monocelididae)

Cannona Faubel & Rohde (Turbellarian)

Preptetos cannoni Barker, Bray & Cribb, 1993 (Digenean)

Acanthobothrium cannoni Campbell & Beveridge, 2002 (Cestoda)

Nematodes

Onyx cannoni Blome & Riemann, 1994

Crustaceans

Baccalaureus cannoni Grygier, 1991

Tardigradida

Batillipes cannoni Kristensen & Mackness 2000

CITATIONS:

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